EPA United States
Environmental Protection Agency R-030

INNOVATIONS IN SLUDGE DRYING BEDS

A PRACTICAL TECHNOLOGY

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United States
Environmental Protection
Agency

October
1987

EPA

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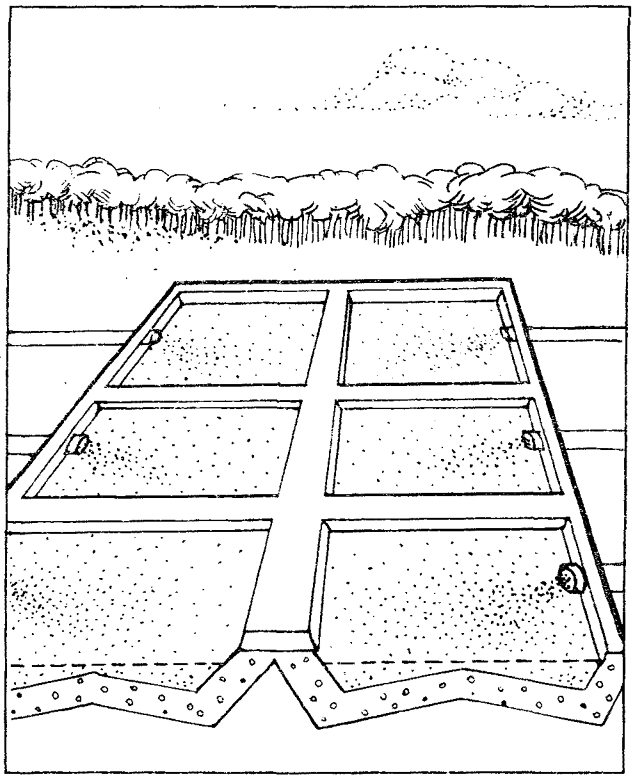

Innovations In Sludge Drying Beds - A Practical Technology

Background
Sand drying beds are still the most common sludge dewatering process at small to moderate sized wastewater treatment facilities in the United States. When suitable land is available, the conventional sand bed can still offer low costs and energy savings but does require significant operational labor. The new EPA Process Design Manual (EPA 625/1-87-014) Dewatering Municipal Wastewater Sludges (available in October 1987) offers updated criteria on sand beds, a rational design procedure, information on the use of polymers and winter time freezing to improve performance, as well as current case studies and design examples.

Among the concepts also discussed in the new manual are Paved Beds and Reed Beds, both of which show promise as alternatives to conventional sand beds.

Paved Beds
Until recently, paved beds used an asphalt or concrete pavement on top of a porous gravel subbase. Unpaved areas, constructed as sand drains, were placed around the perimeter or down the center of the bed to collect and convey drainage water. The main advantage was the capability to use heavy equipment for sludge removal. Experience showed that drainage was inhibited by the pavement so the total bed area had to be greater than a conventional sand bed to achieve the same dewatering results.

A tractor-mounted horizontal auger, or other device may be used to regularly mix and aerate the sludge. This mixing and aeration breaks up the surface crust, which inhibits evaporation, and therefore allows more rapid dewatering than conventional sand beds. Some tractor units now used for this purpose were originally developed for rapid backfilling of trenches or for composting operations and serve well for paved bed dewatering.

Underdrained beds are still used in some locations and in these cases the free water is allowed to drain and then the mixing (auger/aerator) unit is used to accelerate evaporation of the remaining water. In suitable climates, low cost impermeable paved beds which depend on decanting of the supernatant and mixing for enhanced evaporation are used. Figure 1 illustrates a typical cross section of a paved bed using soil cement as the construction material. While paved beds have been constructed with both concrete and asphalt pavements, the most economical approach has usually been soil cement. These completely paved beds have an advantage since the mixer will mix sand with the sludge if operating on a conventional underdrained sand bed. The length and width of the bed can be similar to those used for conventional sand beds. Other features include draw-off pipes for decanting the supernatant in each of the bed corners and a sludge inflow pipe at the center of the bed.

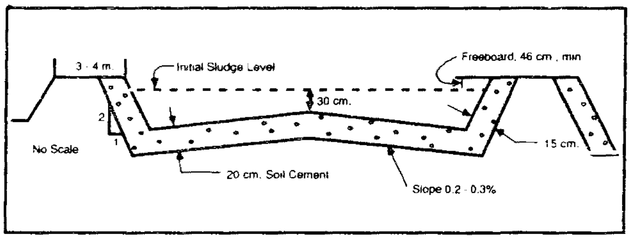

Figure 1. Cross Section of a Paved Bed

If the sludge has good settling characteristics, it may be possible to draw off 20 to 30 percent of the water by decantation. If the sludge has particularly good settling characteristics or if polymers are used, it may be possible to use several fill and decant cycles prior to the evaporation stage. The initial decantation phase might require two or three days for sludge settling and another one to two days to decant supernatant for each sludge layer added. The final evaporative drying period will depend on climatic conditions and on the regular use of the mixing equipment. Solids in the range of 40 to 50 percent can be achieved in 30 to 40 days in an arid climate, for a 30 cm (12 in) sludge layer, depending on the time of the year and on the effectiveness of decantation.

Paved beds can be used in any location, but since evaporation is the major pathway for water loss, the concept is most advantageous in warm, arid and semi-arid climates. Assuming the same degree of effort is expended with the mixer, the design solids loading will be directly related to the potential evaporation for the local area. For example, the design loading rate for a system in Roswell, NM was 244 kg/m^2/year while the loading for a pilot test in Wichita, KS was 127 kg/m^2/year.

Table 1 presents the design equation for determining the total bottom area for a paved bed system. This design area should be divided into at least three beds for all but the smallest facilities to provide operational flexibility. The equation as presented in Table 1 is based on annual averages. The optimum number of beds required can be determined during final design via a month by month analysis of weather records and expected sludge production rates. The system designed for Roswell, NM for example has a total of seven beds, six of which need to be used in December, but only three are required in June due to increased evaporation and decreased sludge production.

$$A = \frac{(0.104)\,(S)\,[(1-s_d)/s_d - (1-s_e)/s_e] + (100)\,(P)\,(A)}{(k_e)\,(E_p)}$$

Where:

A = bottom area of paved bed, m^2

S = annual sludge production, dry solids, kg.

s_d = percent dry solids in the sludge after decantation, % as a decimal.

s_e = percent dry solids required for final sludge disposal, % as a decimal.

P = annual precipitation, m.

k_e = reduction factor for evaporation from sludge versus a free water surface use 0.6 for preliminary estimate, pilot test to determine for final design.

E_p = free water pan evaporation rate, cm/yr.

Table 1. Design Equation for Sizing Paved Beds

The major operational tasks are sludge application, decanting, mixing, and sludge removal. Depending on the time of the year and the size of the operation, the sludge on the bed should be mixed several times a week to maintain optimum conditions for evaporation. Labor requirements at the Roswell, NM system are estimated to be about 0.3 hours per year per metric ton of dry solids processed.

The capital costs for a paved bed system are dependent on the cost of land at the project site. Other cost factors include the containing dikes, the pavement, piping for sludge application and water decantation, the mixing vehicle, and sludge removal equipment. Table 2 compares the costs of a paved bed operation to conventional sand beds for the same location in an arid climate.

Item	Sand Bed	Paved Bed
Number	16	7
Total area, m^2	60,600	26,200
Solids, $kg/m^2/yr$	108	243
Labor, hr/yr	8,580	1,700
Capital costs	$ 1,465,000	$520,000
O & M costs $/yr	$ 100,000	$ 25,000
Present worth	$ 2,500,000	$780,000

Table 2. Cost Comparison - Paved vs. Sand Bed

The new EPA Process Design Manual provides a case study of sludge dewatering using paved beds at the Village Creek Wastewater Treatment Plant serving Fort Worth, TX. In this case, the existing beds were converted to this method. The average wastewater flow is $3.9 m^3/s$ (88 mgd) and the sludge beds cover 78 ha (193 ac), demonstrating that the concept can also be effective in large scale operations.

Reed Beds

This concept combines the elements of an underdrained sand bed and a dense stand of vegetation in the sludge dewatering process. Most of the beds in current operation have been planted with the common reed *Phragmites*; other emergent vegetation has also been used successfully in European systems.

New beds are typically constructed as a deep trench, lined to prevent exfiltration. About 25 cm of gravel covers the underdrain piping and the gravel is overlain by about 10 cm of sand. The root stock is planted on about 30 cm centers and the bed is flooded with water for several weeks to encourage plant development. The freeboard above the sand layer is at least one meter to provide for long-term sludge storage. Sludge is not applied until the plants are well established.

The vegetation is an essential component in the dewatering process. The root system absorbs water which is transpired to the atmosphere. More importantly, the penetration of the plant stems and the root system maintains a permanent pathway for drainage of water from the sludge layers. Reeds and similar plants have the capacity to transmit oxygen from the leaves to the roots so there are aerobic microsites adjacent to the roots which assist in stabilization and mineralization of the sludge.

Stabilized, thickened sludge, at about three to four percent solids is applied in 10 cm layers. The proponents of the concept indicate that a layer can be applied about every 10 days during warm weather conditions. The dewatered sludge remains on the bed and the new layer is applied directly on top of it as compared to conventional sand beds where each layer must be removed prior to the next application.

An operational system in Washington Township, NJ was designed for an annual solids loading of 100 kg/m^2/yr (3.5 m depth of aerobically digested sludge at 3 percent solids). The average loading on 16 operating systems in New Jersey, New York, and North Carolina, is about 81 kg/m^2/yr which is at the low end of the range for conventional sand beds. These systems have been successfully operated in New Jersey on a year-round basis, with only 20 to 30 days downtime for adverse weather conditions. Since the benefits of the process will be minimal during the dormant season and during prolonged freezing weather, it is likely that a longer downtime may be required for locations with severe winters. An alternative, in cold climates, may be to use the same bed for winter freeze dewatering as described in the new EPA manual (reference 1).

A ten-year operational cycle has been planned for the several systems in New Jersey. At the end of this time, the accumulated sludge and the sand layer are removed. A new layer of sand is installed and new vegetation is planted. The residual dried sludge from a typical one-year period is estimated to be about 10 cm deep, so there is sufficient freeboard for a 10-year cycle. An annual harvest or controlled burning of the vegetation is recommended when the plant is dormant but before the leaves are shed. This is necessary to avoid clumps of dead vegetation which would interfere with sludge distribution on the bed.

Multiple beds are required for every installation to allow one bed to be out of service each year and one for emergencies. When a bed is to be cleaned, sludge applications are stopped on that bed in early spring, the vegetation harvested in early fall, and the sludge residue and sand removed by early winter.

The total bed area required will be equivalent to conventional sand beds, or larger, based on the loading rates cited above. The main advantage is the infrequent need for sludge removal and bed cleaning which are some of the most time consuming tasks facing plant operators. Instead of cleaning a sand bed on a frequent schedule every year, the need is extended several years. The major disadvantage is the need for vegetation harvest. This material can be burned, land filled, or composted. The total volume of harvested vegetation and sludge residue on a ten-year operational cycle should be less than the sludge cake volume requiring disposal if the same amount of sludge were dewatered conventionally on a sand bed. The reed bed concept appears to be best suited for small facilities. It might be ideal for managing the waste sludge at remote extended aeration systems where routine sludge wasting is required.

Conclusions

Conventional sand drying beds can still be a cost-effective process for sludge dewatering at small to moderate sized facilities and at large systems where land costs and the climate are favorable. The information provided in the new EPA Process Design Manual on the use of polymers and freeze dewatering in cold climates can be used to improve the performance and efficiency of these sand bed systems. The paved bed with a mixing vehicle offers an effective alternative to conventional sand beds. The reed beds described above seem to offer a low maintenance alternative for the smaller sized systems.

References

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Final preparation, editing and format by Environmental Resources Management, Inc.